

SEISMIC PERFORMANCE OF REINFORCED
CONCRETE SCHOOL IN SABAH

HAMIM BIN SOVESTER

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG



SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Civil Engineering.

(Supervisor's Signature)

Full Name : DR MOHD IRWAN BIN ADIYANTO

Position : SENIOR LECTURER

Date :

(Co-supervisor's Signature)

Full Name :

Position :

Date :



STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : HAMIM BIN SOVESTER

ID Number : AA13127

Date : 14 JUNE 2017

SEISMIC PERFORMANCE OF REINFORCED CONCRETE SCHOOL IN SABAH

HAMIM BIN SOVESTER

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2017

ACKNOWLEDGEMENTS

Alhamdulillah, first and foremost, I would particularly like to express my deepest gratitude to Allah SWT for the guidance and help in giving me the strength to complete my thesis. Praise and peace be upon Prophet Muhammad S.A.W, his family and his companion.

I would like to forward my deepest appreciation to my supervisor, Dr Mohd Irwan bin Adiyanto for the valuable guidance, continuous support, invaluable advice and guidance upon completion my final year project. Thank you for giving me a chance to perform on the completion of my thesis.

During completion of my thesis, I have learnt a lot of things and new knowledge regarding to the causes of earthquake, its consequences and hazardous until I can produce modelling analysis and simulation of an anti-seismic building design. The knowledge is very helpful since earthquake has come as one of the consideration during design process of a structure in Malaysia.

In addition, I would like to express my gratitude to our team members, Nur Amirah Binti Nasai, Farah Aqila Binti Tun Ridhuan and Afiqah Azzera Binti Awang Damit for helping and advising in completing this thesis. They help's a lot from beginning until completion of this project.

Lastly, special thanks to my father, Sovester Gomporo, my mother Janisah Binti Gabbas and my brothers who give me endless support while facing hard time completing this project.

TABLE OF CONTENT

DECLARATION

TITLE PAGE

ACKNOWLEDGEMENTS **ii**

ABSTRAK **iii**

ABSTRACT **iv**

TABLE OF CONTENT **v**

LIST OF TABLES **viii**

LIST OF FIGURES **ix**

LIST OF SYMBOLS **xi**

LIST OF ABBREVIATIONS **xii**

CHAPTER 1 INTRODUCTION **1**

1.1 Background 1

1.2 Problem Statement 3

1.3 Objectives 5

1.4 Scope of Work 6

1.5 Thesis Outline 7

CHAPTER 2 LITERATURE REVIEW **8**

2.1 Introduction 8

2.2 Multiple earthquake phenomenon 8

2.2.1 Foreshock, Mainshock and Aftershock 9

2.3 Ground Motion 11

2.4	Method of Analysis	12
2.4.1	Nonlinear static analysis	12
2.4.1	Nonlinear Dynamic (time history) Analysis	16
2.5	Collapse Structural Analysis	16
2.6	Effect of Multiple Earthquake on Structural Performance	16
2.7	Summary	20
CHAPTER 3 METHODOLOGY		21
3.1	Introduction	21
3.2	Description of 2D Generic RC School Building	23
3.3	Fundamental Period of Vibration, T_1	25
3.4	Design Response Spectrum	25
3.5	Design Ground Acceleration, a_g	27
3.6	Ground Motion Records	29
3.6.1	Seismic Sequence	30
3.7	Section Analysis by Using Cumbia	33
3.8	Plastic Hinge Properties at Member's End	36
3.9	Data and Analysis	38
3.10	Summary of Procedure	38
CHAPTER 4 RESULTS AND DISCUSSION		40
4.1	Introduction	40
4.2	Nonlinear Time History Analysis	40
4.2.1	Lateral Displacement	40
4.2.2	Interstorey Drift Ratio	44

CHAPTER 5 CONCLUSION	47
5.1 Conclusion	47
5.2 Recommendation	48
REFERENCES	49
APPENDIX A MAXIMUM LATERAL DISPLACEMENT	54
APPENDIX B DISTRIBUTION OF MAXIMUM LATERAL DISPLACEMENT	56
APPENDIX C INTERSTOREY DRIFT RATIO	58
APPENDIX D DISTRIBUTION OF INTERSTOREY DRIFT RATIO	60

LIST OF TABLES

Table 1.1: List of selected tremors during the 2015 Ranau earthquake.	4
Table 2.1: The detailed of three earthquake	9
Table 3.1: Weight of materials	23
Table 3.2: Main parameters to develop Type 1 design response spectrum	26
Table 3.3: Importance classes and importance factors for buildings	27
Table 3.4: NFE Ground Motion Records	29
Table 3.5: Scaling of real near field earthquake to response spectrum	30
Table 3.6: Combination of single earthquake to generate multiple earthquake.	30
Table 3.7 Moment-curvature data (CUMBIA)	34
Table 3.8: Parameters used in this study	38

LIST OF FIGURES

Figure 1.1: Epicentre of Ranau, 2015 earthquake	2
Figure 1.2 Effect of sequence of ground motion	6
Figure 2.1: Comparison between foreshock, main shock and aftershock	9
Figure 2.2: Comparison of the (a) NFE and (b) FFE	10
Figure 2.3: Capacity Curve	13
Figure 2.4: Strength and deformation points	14
Figure 2.5: Sequence of hinges formation	14
Figure 3.1: Flowchart of research procedure.	21
Figure 3.2: 2D generic model	22
Figure 3.3: Seismic hazard map for Peninsular Malaysia	28
Figure 3.4: Seismic hazard map for Eastern Malaysia	28
Figure 3.5: Typical profile of generated ground motion with 100s gaps.	31
Figure 3.6: Moment-curvature curve	34

Figure 3.7: (a) Force-Displacement Relationship and (b) Defining Frame Hinge Property	35
Figure 3.8: Assignment of the plastic hinge to the structural member's end	36
Figure 4.1: Mean lateral displacement (m).	41
Figure 4.2: Mean Interstorey Drift Ratio (%)	45

LIST OF SYMBOLS

Δ	Displacement
Δ_{\max}	Maximum displacement
R	Force Reduction Factor
V	Shear
Q_k	Live load
G_k	Dead load
f_{cu}	Concrete compressive strength
f_y	Yield strength of steel
C_t	Coefficient
F_b	Base shear force
q	Behaviour factor
γ	Base Shear Coefficient
T_1	Fundamental Period
T_B	Lower limit of the period of the constant spectral acceleration branch Beginning of the constant displacement response
T_D	range of the spectrum
S	soil factor
$S_d(T)$	design spectrum
B	lower bound factor for the horizontal design spectrum (0.2)

LIST OF ABBREVIATIONS

FEMA	Federal Emergency Management Agency
BS	British Standard
MMD	Malaysia Metrology Department
JMGM	Jabatan Mineral and Geoscience Malaysia
RC	Reinforced Concrete
FFE	Far Field Earthquake
MDOF	Multi Degree of Freedom
NEHPR	National Earthquake Hazards Reduction Program
NFE	Near Field Earthquake
IDR	Interstorey Drift Ratio
SDOF	Single Degree of Freedom
UBC	Uniform Building Code
USGS	U.S. Geological Survey
DNFS	Near Field Single Earthquake on Soil Type D
DNFR	Near Field Multiple Earthquake on Soil Type D